ORACLE — An Information Broadcasting Service Using Data Transmission in the Vertical Interval

By G. A. McKENZIE

The Independent Broadcasting Authority is at present testing a system for information broadcasting using binary-coded data in the vertical interval of the television signal. At the receiver, individual "pages" of information may be selected from the fifty different pages available in the present trial system. The information is then stored and may subsequently be displayed continuously. It is expected that the service would eventually be used for information such as weather forecasts and stock prices. The present system allows for the transmission of simple graphics and further extensions to the facilities are envisaged.

Introduction

The use of "Insertion Data Signals" to carry information in the vertical interval of television signals for service use has been reported from several sources (for example, Refs. 1–4). In a paper describing "SLICE" — equipment for data transmission on the Independent Broadcasting Authority (IBA) network for the purpose of labeling of signal sources — published in September 1972 in the United Kingdom,[5] Hutt looked forward also to domestic use of such an information channel in the U.K. Insertion data systems for such information broadcasting have been reported (for example, in Refs. 6 and 7), and interest in this topic has been increasing as the estimates of the cost of the necessary receiver hardware continue to fall because of the availability of LSI (large-scale integration) techniques. Both the British Broadcasting Corp. (BBC) and IBA are now conducting experimental transmissions in the U.K. using systems called CEEFAX[8] and ORACLE,[9] respectively.

This paper describes the main features of IBA's ORACLE system and gives some information on current experiments. ORACLE (an acronym for Optional Reception of Announcements by Coded Line Electronics) is now at an advanced stage of engineering development, with continuous test transmissions. Studies are currently in progress with the objects:

(1) to determine the best form of modulation for the data;

(2) to determine the specification for data and display format;

(3) to determine other characteristics, for example those which may be desirable from the subjective point of view; and

(4) to determine the course of further development.

Presented on 18 October 1973 at the Society's Technical Conference in New York by G. A. McKenzie, Automation and Control Section, Experimental and Development Dept., Independent Broadcasting Authority, 70 Brompton Rd., London SW3 1EY, England.

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Data Format — General

The form of modulation at present employed for the inserted binary data is "complemented element" in which a "1" element followed by a "zero" element represents binary digit "1" and a "zero" element followed by a "1" represents a binary digit zero. This is illustrated in Fig. 1. The signal has many zero-crossings at intervals of 200 ns so that the rectified signal contains a strong timing component at 5 MHz. The receive clock may therefore be generated accurately, even in the presence of noise and distortion.

The clock frequency is 5 MHz at present. Confidence had been gained in over-air reception of this form of modulation in experiments conducted by the IBA in 1971.[10] Subsequently the method was adopted for experimental use by other broadcasting organizations in Europe.

The sequence of the data inserted into one television line is as illustrated in Figure 2. As may be seen, each television line used for data transmission contains 123 bits and includes a "segment" of 10 characters of the message which is ultimately to appear on the viewers' screens. In the present system (the 625-line System I[11]), 40 characters form each line or "row" of the message as it will appear on the screen, and four segments must therefore be transmitted for each row of characters. These might be transmitted in two successive fields by the use of lines 17, 18 and 330, 331, but the system also allows for the use of other combinations — for example the use of line 16 only — to support the transmissions. Line 16 was chosen as it is an accepted standard of CCIR (the International Consultative Committee on Radiocommunications) that this line should be reserved for data transmission purposes.[12]

Referring again to Fig. 2 the following features may be described:

"Run in": allows receiver decoding clock synchronization.

"Start": contains two breaks in the complementation code. The unique code increases security of the detection of the start code of the ORACLE message, differentiating against "picture" information without reference to the standard television synchronizing signals.

"Data Label": allows for future systems in which different types of information may be transmitted.

Page Number: refers to the page number which would appear on the viewers' screens; 6 bits are allowed here at present but this may later be changed to 8 bits BCD (binary-coded-decimal).

Row Number: allows the particular row of the displayed caption to be addressed.

Segment Number: allows the particular segment of a row to be addressed.

Sub-Page Number: allows for the transmission of extra material, or of more detailed information relating to a page.

Commands ("Spare," "Display Type," "Control Bit," "Clear"): allow for the interpretation of the following characters, and would therefore permit (for example) a change of mode from segment to segment.

Characters: 8 bits are allowed per character and typically this would provide for a full ASCII character set and special symbols. (ASCII — American Standard Code for Information Interchange.)*

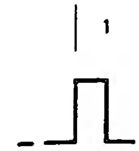
Power Density Frequency Spectrum

The spectrum for the complemented element transmission has been calculated by Hutt[15] and is reproduced in Fig. 3. As may be seen there is a strong component at 2.5 MHz which allows for accurate extraction of the clock phase even in noisy conditions and there is no dc component, which allows simplification of the slicing and detection circuits in the receiver.

"Adaptive" Mode of Transmission

ORACLE transmissions have separately-addressed segments. This means that the transmission may be "adapted" to page contents so that segments which do not contain information characters are not transmitted. This reduces the transmission time. A typical ORACLE "magazine" of 50 pages — that for 8 August 1973 — was analyzed and it was found that use of the adaptive mode meant that the magazine could be transmitted in 68% of the time which would have been needed if character "blanks" were transmitted. It was also found that adaptive transmissions with addressed blocks of data one segment long gave a

*ASCII is concerned with a binary code which may be used to define sets of letters, numbers and other symbols for use in data processing and transmission. If 7 bits are available for each character then $2^7 = 128$ characters may be coded and the Standard defines the code to be used for each.



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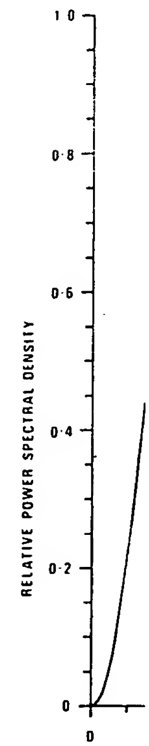

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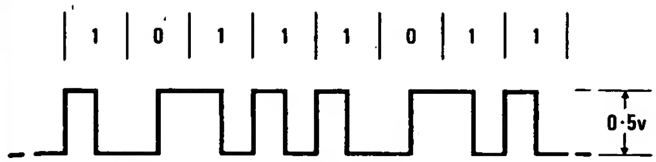

Fig. 1. The "complemented element" form of modulation, presently employed for ORACLE transmissions. Signals extend from black level. The element — or clock — rate is approximately 5 MHz (data rate = 2.5 Mb/s approximately).

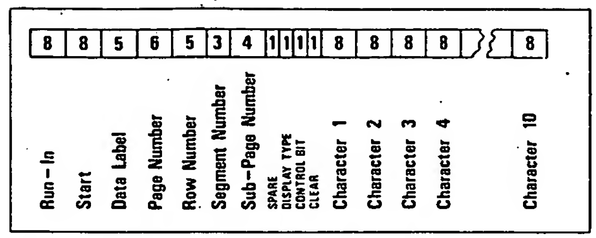

Fig. 2. Allocation of data bits within one television line. For "System I" the line period is 64 ms and the period available for data is about 52 ms.

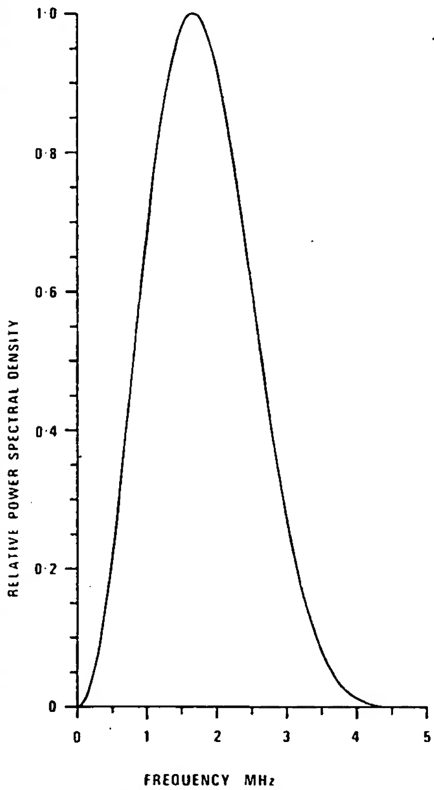

Fig. 3. Power-density spectrum for the complemented element transmission. It represents both single bit and random pulse train. The spectrum is well-situated in the video bandwidth (of 5.5 MHz) with very little energy below 100 kHz or above 4.5 MHz, having zeroes at zero frequency and at 5 MHz.

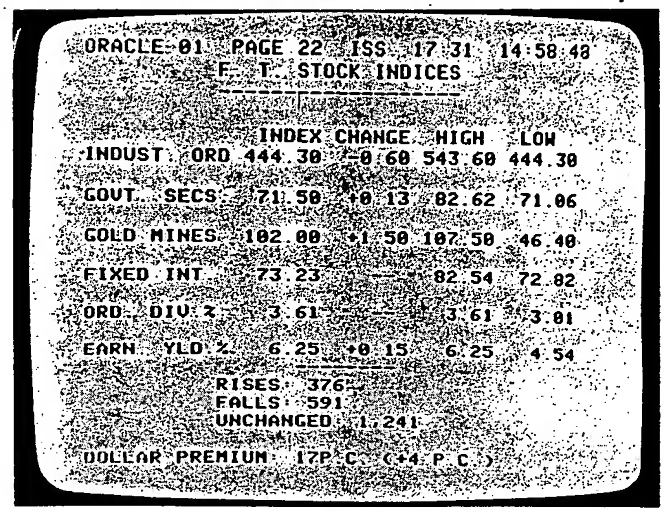

Fig. 4. A typical page from the present engineering test ORACLE system. On the top line (left to right) are shown the ORACLE page numbers being transmitted, the number of the page which is being displayed, the time of issue of the information and the clock time.

transmission time which was 82% of the time which would have been needed if blocks had been one complete row in length.

A typical page of an ORACLE magazine is shown in Fig. 4.

The ORACLE Transmitter System

The experimental transmitter system is based on a small general-purpose computer. A block diagram of the hardware is shown in Fig. 5. The computer system actually in use at present is a Honeywell DDP 516. This system supports other engineering work as well as the ORACLE experiment and is a bigger system than would be needed for a dedicated ORACLE system, even after allowing for many "magazines" in store. The present system uses only a small part of the capacity of a 3.2-megaword disc. Computers such as the Honeywell H-316 might be used in a dedicated system, with a small disc unit.

The computer outputs the 112 bits for each television line in the form of seven 16-bit parallel words to the interface/controller unit. Data pass serially from there to the Data Coder which actually constructs the signal. The signal is then inserted into the main video path by the use of standard inserter equipment of IBA design.[13] This equipment contains fast electronic switches to allow the video signal to be replaced during the time of a preselected line in the vertical interval, by data fed to one of four input sockets.

The system allows editing to proceed without interruption to the normal flow of data from the disc store to the data inserter equipment. The store may be large enough to allow storage of hundreds or even thousands of pages, complete or in preparation, so that magazines may be changed instantly, under the control of an editor, to suit time of day, day of week, and so on. Also, many more editing positions may be used, to allow contributions from "specialist" editors. The use of a general-purpose computer also permits direct connection of the system to external sources of information such as stock exchange quotations.

Software

Software written for the experiments allows for the recall of any of 50 pages of information for editing on the visual display unit (VDU) without interference with the normal running of the system. When editing and checking are completed the new page may be inserted into the system without any pause or discontinuity in transmission.

Data for new pages may also be entered by punched paper tape. The "pages" may be output at any time to the line printer, for record purposes.

Software features are perhaps best illustrated by a list of keyboard functions as follows:

EX–Contents of one page are transferred to another (with the exception of page numbers).

DI–Display (the specified page).

WR–Write — If a page is currently being displayed on viewers' screens this command causes the screen to be cleared and then writes the updated page.

AM–Amend — This command doesn't clear the viewers' screens and only the amended portion will be seen to change.

TA–This command allows tape to be read from the tape reader into computer store.

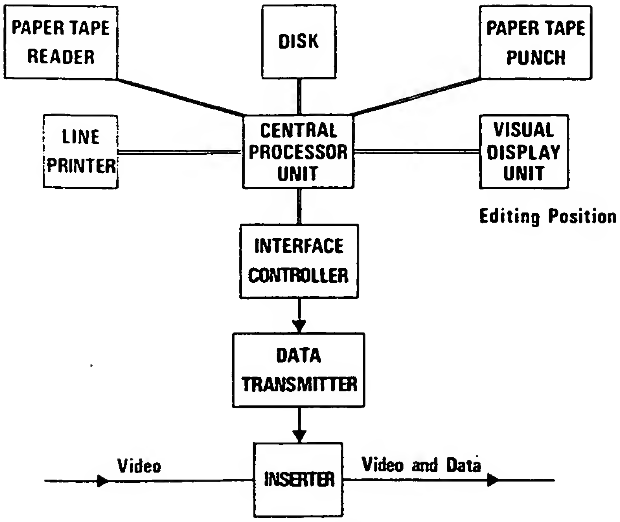

Fig. 5. Block diagram of the ORACLE originating-system hardware.

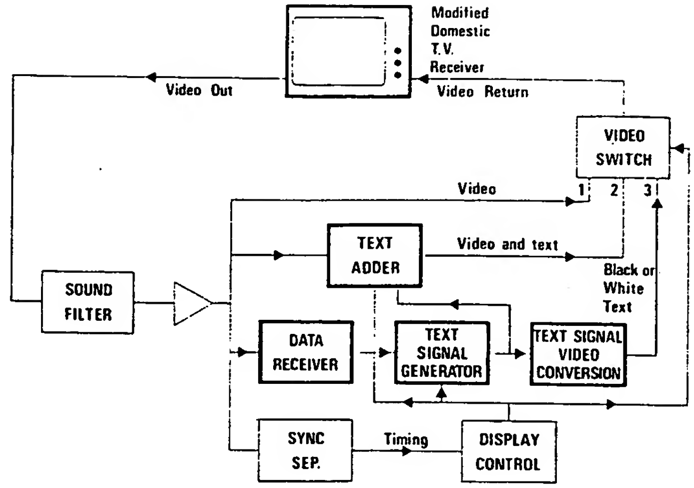

Fig. 6. Experimental demonstration receiver equipment employing a modified domestic TV receiver.

DA–(followed by date) Enters the date into store.

PR–Print — Allows the contents of the magazine to be printed on a line printer.

OR–Return to ORACLE — This starts the transmissions of ORACLE.

ST–This stops the ORACLE transmissions altogether, but allows editing to proceed.

The system may be further refined by software in the future, to provide facilities such as:

(1) Interactive optimization of layout for minimum transmission times.

(2) Interactive design of graphics for acceptable transmission times and appearance.

(3) Calculation and display on demand of the access times for information from any page.

(4) Storage of extra pages or complete magazines which are in process of compilation or which it is desired to display at particular times.

(5) Hard copy record of individual pages or magazines.

(6) Automatic index updates.

(7) Automatic logging of "air-time" of particular pages or page content.

(8) Code or format conversion from other information systems.

(9) Captions for the deaf.†

The Experimental Receiver

Figure 6 is a block diagram of the receiver. The mechanism of operation is as follows. The entire video signal is passed to the data receiver which checks for the presence of the unique ORACLE start code. On detection of this, the code corresponding to the selected page number is sought. On coincidence, the page information is fed to the text signal generator input store. Twelve words at a time are clocked into the store; the first word defines the row and segment address (refer again to Fig. 2). At the appropriate time the input store is clocked into the page store and thence into the row store. The row store circulates to drive the character generator and then feeds back its contents to the page store. This means that a complete page can be displayed continuously even after the input data signal is removed.

From the text signal generator the signal may either be added to the video in the text adder or it may be substituted for the video signal through the text signal video converter.

It is anticipated that future production

†By using a "special" page number, captions may be transmitted within one field of the nominal point in program time. For further information on a similar system which is intended as a service for the deaf see paper by Ball and Wells.[7]

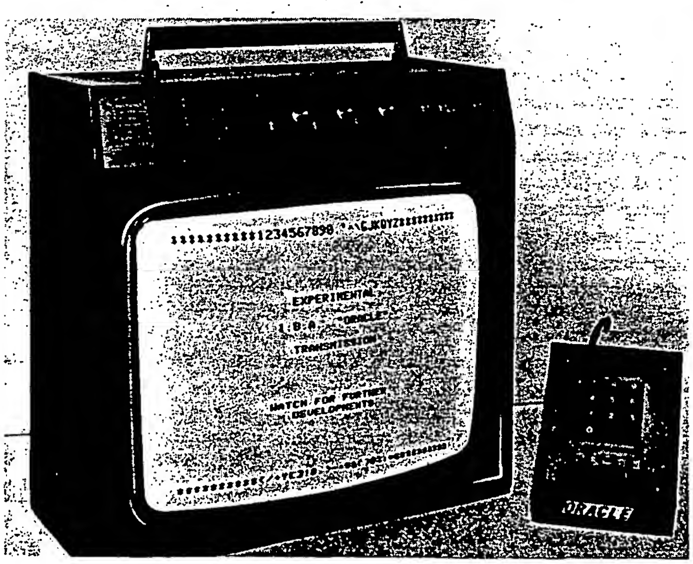

Fig. 7. Modified receiver and ORACLE control box.

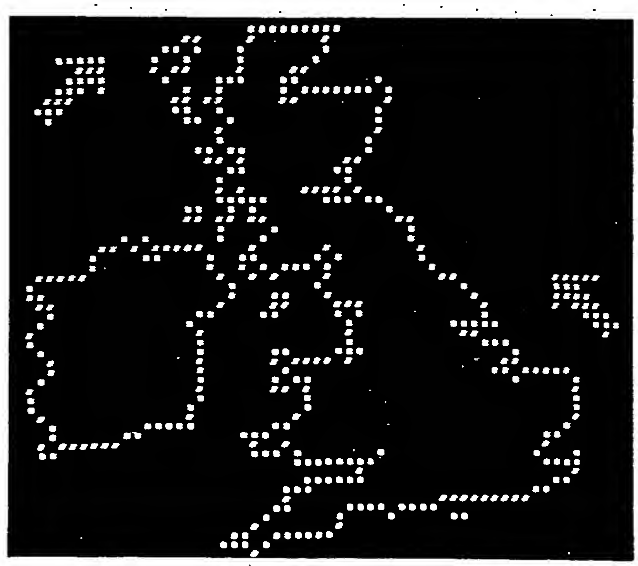

Fig. 8. An early stage of development of an ORACLE graphics facility. Each of the 64 ASCII characters is interpreted in the graphics mode as a different arrangement of six dots in a 2 × 3 matrix.

receivers would concentrate the equivalent of this ancillary equipment into one or two LSI (large-scale integration) packages and that the consequent increase in cost for a 25-in (64-cm) color receiver would be only about 10%.

A standard domestic TV receiver was modified (using discrete components) to display the ORACLE test transmission from the London IBA transmitter. The receiver modification was simple — the video signal path was interrupted at a suitable point to allow ORACLE text decoding and text addition in external equipment, as shown in Fig. 6. The use of such a standard receiver was helpful in that it allowed representative demonstrations of the system to be given to nontechnical audiences in the laboratory. A general view of the modified receiver and control unit used in the laboratory tests is shown in Fig. 7.

The required page number was selected on the numeric keyboard on the control box which also allowed for a choice of display modes — white on black ground, black on white ground (as shown), or superimposition on the normal program material. The text shown on the display in this case relates to an experimental transmission which has been radiated throughout program time from the IBA's London UHF transmitter since 6 April 1973.

Display Format

For the experimental system a page format of 22 rows of 40 characters each has been adopted. This gives the following system characteristics, with two lines per field in use for the transmissions.

Characters per row	40
Rows per page	22
Characters per page.	880
Maximum page transmission time	0.9 s
Mean access time to the selected page for 50-page magazine having average contents‡. .	16 s

The first row of each page carries an identification and in addition the date and time in hours, minutes, seconds so that every viewer, no matter which of the ORACLE services he is watching, will always have available the equivalent of an accurate digital clock. As an example the first row might read:

ORACLE 06 PAGE 18 ISS 10:10
14:53:07.

This would identify the page being transmitted at that particular moment as 06, the page of information being displayed as page 18, the time at which the information was current as 10:10 and the present time to the nearest second.

‡Note that a "50-page" magazine actually has a total of 55 pages to allow for six transmissions of the "Index" page in each cycle. Thus the mean access time for the Index is about 2.7 s.

ORACLE Graphics

The present experimental system allows for transmission of simple line drawings such as maps for weather forecasts. The graphics information is displayed by use of a simple "dot" 2 × 3 matrix in place of each character, when the "display type" bit is set in the command word (See Fig. 2). Figure 8 — a rather stylized but quite recognizable map — illustrates the present early stage of development. The potential increase in cost for production receivers to display graphics information of this sort is very small. This is because the pattern of "dots" forming each graphics "character" may be formed simply from ASCII-coded characters, the decode process relying upon a simple shift register instead of a read-only memory. (ROMs are arrays of semiconductor storage elements. The state of each element may be set to represent either 1 or 0 in a programing process after which the array forms a permanent store of the desired pattern of 1's and 0's. Such a pattern could, for example, represent all the characters of an ASCII-coded set.)

Standardization of Public Information System Characteristics

The first engineering test transmissions in the U.K. began from the London IBA transmitter on 3 April 1973, and these were followed on 6 April 1973 by continuous transmissions throughout program times. Line 16 of the television signal was used (i.e., only one TV line every other field) to transmit the "test caption" noted in Fig. 7. On 20 May 1973 parallel transmissions were made using lines 17, 18, 330 and 331. These more elaborate transmissions were of 50 different pages of ORACLE information from the computer system which has been described. Such full 50-page transmissions are not made continuously at the present time but are repeated at intervals for special demonstrations and tests. Currently, preparation is being made for more elaborate test caption transmissions, perhaps from two or three IBA transmitters in different parts of the U.K.

These tests represent only the first stage in a program of work in cooperation with the BBC and the British Radio and Electrical Mfrs. Assn. (BREMA) which aims to support studies of possible transmission standards for a public information service for the U.K. Until one standard is agreed, regular public services cannot be started.

Standardization studies center on two main aspects:

(1) The actual form of modulation to be used for the binary coded data; and

(2) The page "format" (i.e., number of characters per row, number of rows per page), and its relationship to the data transmission format.

Regarding the form of modulation, it is planned that two systems will be tested jointly by IBA and BBC engineers at various field locations. The test signals will be provided by transmissions at UHF by both the BBC and IBA and these will allow comparisons of error rates and the general subjective impressions of the CEEFAX and ORACLE systems in field conditions. The BBC CEEFAX system currently uses NRZ (nonreturn to zero) coding with clock frequency 4.5 MHz, and, as has been described, the IBA ORACLE system uses "complemented element" transmission with clock frequency 5 MHz. "Complemented element" signals may be considered identical in their power spectrum to "biphase" signals, in calculations of the receiver bandwidth requirements. For a discussion of NRZ, biphase and other classes of binary baseband signals see, for example, Houts and Green.[14]

It is regarded as desirable that the service areas for data transmissions should match as closely as possible those for the normal color TV services. Multipath transmissions have been reported to have been troublesome to other workers, and particular attention will be paid to this form of distortion in the BBC/IBA tests.

Conclusions

ORACLE — an experimental system for transmission of information to television viewers — has been described. This system uses data transmission in the vertical interval of the television signals. BBC and IBA joint field tests of this and of an alternative BBC system — CEEFAX — are in progress, with the aim to reach agreement on a joint proposal for a standard system for the United Kingdom.

Acknowledgments: The author wishes to record his indebtedness to his colleagues and in particular to Peter Hutt without whose energetic team leadership the fast progress of the ORACLE project would not have been achieved. The author also wishes to thank the IBA's Director of Engineering, Howard Steele, for permission to publish this paper.

References

1. J. Guillermin, J. Dumont and Y. Guinet, "Transmission of remote control and identification signals within audio and video channels in radio and television broadcasting," *IEE Conference Publication No. 25*, Nov. 1966.
2. Editorial on Japanese Technology: "Pulses on a television signal control station in network," *Electronics*, Feb. 6, 1967.
3. T. V. Anderson, "The vertical interval: A general purpose transmission path," *IEEE Trans. on Broadcasting*, Vol. BC-17, No. 3, Sept. 1971.
4. D. D. Davis, J. L. Jespersen and G. Kamas, "The use of television signals for time and frequency dissemination," *Proc. IEEE — Letters*, June 1970.
5. P. R. Hutt, "A system of data transmission

in the field blanking interval of the television signal," *IEE Conference Publication No. 88*, Sept. 1972.

6. RCA Homefax System, *RCA Engineer, 16:* No. 5, Feb./Mar. 1971.
7. J. E. D. Ball and D. R. Wells, "Encoded captioning of television for the deaf," *8th International Television Symposium*, Montreux, Switzerland, May 1973.
8. BBC Research Dept., "CEEFAX — A survey of facilities," *Technical Memorandum No. GE-1007*, Feb. 1973.
9. IBA, "Broadcasting the Written Word," April 1973.
10. P. R. Hutt, "Line 16/329 data transmission — A note on some experimental measurements," *IBA Internal Report*, Nov. 1971.
11. IBA, "Specification of television standards for 625-line System I transmissions," *IBA Tech. Review*, No. 2, Sept. 1972.
12. CCIR, Report No. 314-2, Note 2.9.
13. I. Lever and J. Schaffer, "Insertion test signal equipment," *Report of the Joint Conference on Television Measuring Techniques*, IERE, May 1970.
14. R. C. Houts and T. A. Green, "Comparing bandwidth requirements for binary baseband signals," *IEEE Trans. on Communications*, Vol. Com-21, No. 6, p. 776, June 1973.
15. P. R. Hutt, "A system of data transmission in the field blanking period of the television signal," *IBA Tech. Review No. 3*, June 1973.

A Novel Television Add-On Data Communication System

By PATRICK T. KING

A system for adding an auxiliary data channel to a standard NTSC television signal has been developed by taking advantage of the fact that for most scenes video voltage levels are very low in 2.5-MHz region. No use is made of the vertical or horizontal blanking intervals. A low-amplitude subcarrier is inserted at an odd multiple of one-half the line-scanning frequency after being biphase-modulated by a specially clocked data stream. The signal is essentially invisible on a standard receiver but when processed by an add-on decoder the original information modulated on the signal may be recovered and displayed on the receiver screen. A 21-kb/s data rate has been obtained with acceptable error rates. Applications of the add-on data communication system include: multilanguage subtitles, subtitles for the deaf, network communications and teaching aids.

MUCH ATTENTION has been given recently to using the vertical and horizontal blanking intervals of a television signal to carry additional visual information (ancillary signals). Such systems can display printed or pictorial information on a properly modified receiver along with the ordinary picture for the convenience of the viewer. In this paper we shall discuss a way to transmit such information—not using the blanking intervals—but instead using a part of the video signal spectrum where the video voltage levels are low for both chrominance and luminance.

System Principles

Examination of the video frequency spectrum of typical televised scenes shows that the video energy is a minimum between 2 and 3 MHz (Fig. 1). A frequency in the 2.5-MHz region was therefore selected as a reasonable compromise between perception of add-on interference in either the luminance or the chrominance channel.

Those who are familiar with the development of band-shared color television systems such as the NTSC system will recognize that an odd multiple of half the line-scanning frequency was chosen for the add-on subcarrier because such a signal goes through an odd number of half-cycles during each television line and thus alternates in phase from line to line. This signal, when displayed on a television screen, will be of relatively low visibility because the signals on each time successive line are of opposite phase and tend to visually cancel each other.

Figure 2 shows the results of some subjective tests in which the test subjects were asked to determine for various video color scenes at which add-on subcarrier level they "barely perceived" interference to the video display at a distance of 4 times picture height. The horizontal axis represents the ratio in decibels of add-on signal-to-peak video.

Transmitter Operation

Figure 3 is a block diagram of the add-on transmitter. The television signal comes from any standard composite video source and would normally be the video modulation input to the transmitter for conventional television transmissions. The video signal is fed to the adder circuit where a low-level add-on subcarrier is added to the video signal only during the active portions of the picture. Figure 4 shows a video signal (A) and the add-on signal (B), not to the same vertical scale. The add-on signal is not transmitted during the horizontal and vertical blanking intervals. The add-on subcarrier is maintained at a level sufficiently low so that no visible interference can be seen on the television receiver screen.

Presented on 18 October 1973 at the Society's Technical Conference in New York by Patrick T. King, Hazeltine Research, Inc., 5445 W. Diversey Ave., Chicago, IL 60639.

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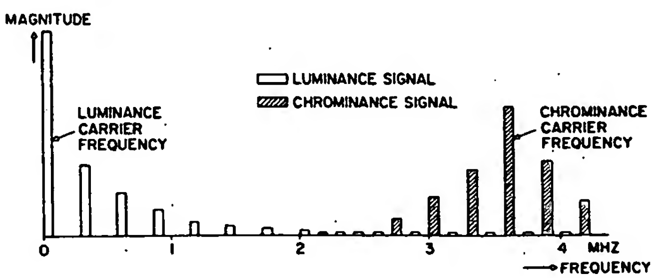


Fig. 1. Typical video frequency spectrum.

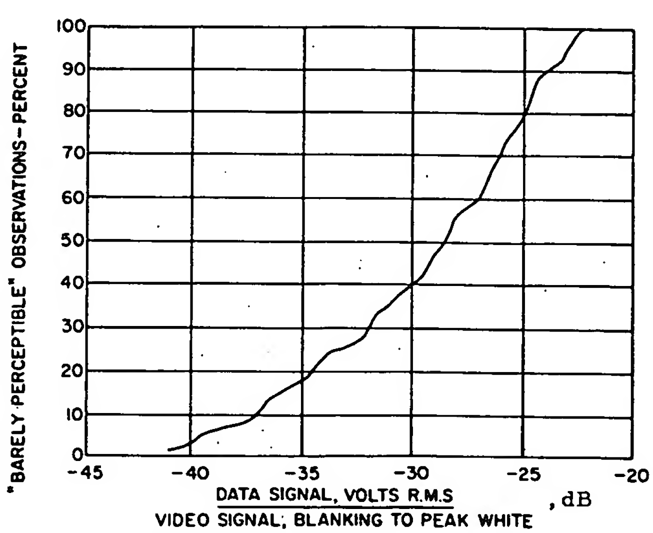
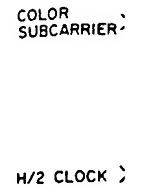


Fig. 2. Perception of add-on signal.



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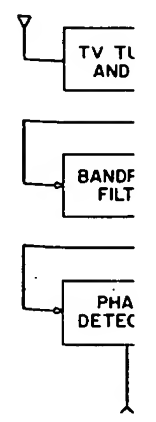

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